NIMBUS-D SOLAR-CONVERSION POWER SUPPLY SUBSYSTEM

QUARTERLY TECHNICAL REPORT NO. 1
15 SEPTEMBER 1967 THROUGH 15 DECEMBER 1967

Contract No. NAS5-10470

Prepared by

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for

Goddard Space Flight Center
National Aeronautics and Space Administration
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PREFACE

This is the first in a series of quarterly technical reports on the development of the Solar-Conversion Power Supply Subsystem for the Nimbus-D Meteorological Satellite. This project is being conducted by the Astro-Electronics Division (AED) of RCA for the National Aeronautics and Space Administration (NASA) under Contract No. NAS5-10470. This report contains data on RCA activities and plans that relate to the technical and schedule pursuance of the contract objectives, and covers the period from September 15, 1967 through December 15, 1967.

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SECTION 1

INTRODUCTION

A. CONTRACT OBJECTIVES

The objective of Contract No. NAS5-10470 is to furnish a Solar Conversion Power Supply Subsystem for use with the Nimbus-D Meteorological Satellite. This configuration will be identified as the Nimbus-D Solar Conversion Power Supply Subsystem.

The contract provides for the manufacture of one flight model and a set of three spare storage modules. The solar conversion power supply subsystem, consisting of one control module, eight storage modules, and solar array (2 solar platforms), will be nearly identical to the equipment supplied under Contract NAS5-9668. Assembly numbers are as follows:

Control Module	RCA 1759712-501
Storage Module	RCA 1759580-501
Solar Platform	RCA 1756475-501

All special test equipment required for the manufacture and test of the flight model equipment was manufactured and assembled under previous contracts.

B. SUBSYSTEM DESCRIPTION

The Solar Conversion Power-Supply Subsystem consists of eight identical storage modules, one control module, and two solar-cell platforms. Each storage module contains a battery consisting of 23 series-connected, nickel cadmium cells and a group of electronic circuits designed to provide control and protection for the battery and other power subsystem components. These circuits and the battery are housed in cast-magnesium containers with sheet-magnesium covers. The control module consists of additional power subsystem electronic circuits housed in a machined-aluminum container. The solar array consists of two solar-cell platforms containing 10,956 N-on-P silicon solar cells, which are mounted on one side of the sun-oriented platforms. The purpose of the subsystem is to provide the spacecraft with electrical power; during satellite day, the solar array converts solar radiation to electrical energy that is supplied to the spacecraft subsystems and the batteries (charge cycle). During satellite night and peak daytime-load periods, the batteries supply the power to operate the spacecraft subsystems.

C. CONTRACT DATA

A stop-work order, NASA letter 12042 dated December 8, 1967, placed a hold on the fabrication and test of the solar platforms, control module, and storage module. The timely procurement of storage cells, storage module castings, and control module castings and all electronic parts will be continued.

SECTION 2

SOLAR PLATFORM

A. GENERAL

Each solar platform consists of a solar-cell mounting structure (substrate) solar cell modules, a transition section, a latching assembly, a motor-drive and gear reduction unit, and a control-shaft clamp.

B. TOOLING

Solar platform tooling was inventoried and preparation of the engineering drawings was initiated.

C. SOLAR-CELL MODULES

1. Introduction

Nimbus solar-cell modules manufactured by the Electronic Components and Devices (ECD) of RCA at Mountaintop, Pennsylvania were measured under a tungsten light source in the solar laboratory. The module types and their quantities were as follows:

ten cell	1074
six cell	182
three cell	66
four cell	8

2. Test Method

All solar cell modules received from the manufacturer were inspected and tested as outlined in the Nimbus-D Solar-Cell Module Evaluation Program (Refer to Appendix I). The standard cells (N-24, N-47, and N-51) used to calibrate the light source, were obtained from the Nimbus-B Solar Conversion Power Supply Program, Contract NAS5-9668. The listed calibration values for these cells were obtained by tests conducted at the Jet Propulsion Laboratory at Table Mountain on May 18, 1967. The test descriptions and results are contained in Section IV of the "Nimbus-B Solar Conversion Power Supply Subsystem, Quarterly Technical Report Number 7," (AED-R-3205) issued August 15, 1967. The listed calibration values were adjusted by the intensity factor of 136.6/139.6 to make the light level compatible with previous Nimbus tests at an air-mass-zero equivalent intensity of 136.6 mw/cm^2. A temperature correction was also applied to establish a calibration level of 25° C.

3. Test Conditions

The calibration of the illuminator, performed every four hours of the 12 test days, yielded the same results each time, i.e., the cell selected as most representative after the three cell cross check (round robin) was always N-24 (refer to Appendix I, Paragraph D5, steps c through g). The intensity pattern variation over the ten-cell positions was within ±1.2 percent on every test. The temperature variation never exceeded ±1°C over the ten cell positions.

4. Test Data Summary

The mean current for the 10-cell modules of the Nimbus-D solar platforms and the 10-cell modules of the Nimbus-C solar platforms compiled in 1965 are presented in Table 1. The current outputs of the Nimbus-D modules are approximately 1-percent higher than the Nimbus-C data, but the distribution was not as tight. The mean open-circuit-voltage (V_{oc}) and distribution for Nimbus-D solar cells was 596 mv and 3 mv, respectively; the mean V_{oc} and distribution for Nimbus-C was 594 mv and 4 mv, respectively.

All the data obtained during the Nimbus-D 10- and 6-cell module tests was presented in histogram format using the computer program presented in Appendix II. The histograms, presented in Appendix III, may be used for module matching prior to assembly. All the three- and four-cell modules met the minimum electrical requirement. Five of the six-cell modules, and 48 of the 10-cell modules failed to meet minimum electrical requirements. Four of the rejected 10-cell modules were examined with a 20X microscope. There appeared to be no obvious reason for the failure.

At the time of the electrical evaluation, the solar-cell modules were scheduled for electrical tests only, no troubleshooting or analysis was performed.

Table 1. MEAN CURRENT AND DISTRIBUTION

Voltage Level	Mean Current (ma)		Standard Distribution (ma)	
	Nimbus D	Nimbus C	Nimbus D	Nimbus C
0.27	1328	1314	19	13
0.37	1307	1293	17	13
0.46	1223	1208	18	9

D. SOLAR PLATFORM Q-BOARD

Fabrication of the Q-board has been completed and evaluation tests have been started.

SECTION 3

CONTROL MODULE

The engineering drawings have been reviewed, and procurement of all parts is in progress.

SECTION 4

STORAGE MODULE

A. GENERAL

Each storage module consists of a two-piece magnesium housing, 23 nickel-cadmium storage cells, and an electronic board. Eight storage modules are supplied with the flight module.

B. STORAGE CELLS

1. Procurement

A purchase order has been placed with the General Electric Co., Battery Products Section, for the procurement of 300 nickel-cadmium storage cells (Part No. RCA 1849586-1, Rev. C). The vendor's best delivery schedule is as follows: 150 cells on March 25, 1968 and 150 cells on April 29, 1968.

2. Terminals

An investigation was made upon the proposal to alter the negative terminal of each cell as a result of two problems experienced on the Nimbus-B Solar Conversion Power Supply Subsystem Program. The problems were as follows:

- Some terminals were found to be inadequately welded to the cell cover.
- Soldering of some terminals was extremely difficult.

A thorough study of the various proposals submitted revealed that a major development effort would be required to obtain a material and configuration that would correct the existing problems and not create new problems. Therefore, the Nimbus-B negative type terminals, subject to the following corrective actions, were selected for use.

- All negative cell-terminals will be given a 20-lb pull test by the cell vendor or cover vendor
- Wires will not be soldered to the cell terminals during cell acceptance testing. (When repeated soldering was eliminated on the Nimbus-B program, the soldering problem was not experienced).

C. CASTINGS

1. Procurement

Side plate design modifications have been incorporated into the engineering drawings and purchase orders for fabrication of the following storage module housing parts have been placed:

- Storage Module Housing Casting — RCA 1173794 Rev. L, from Arwood Corporation, Tilton, N. H.
- Storage Module Side Plate Casting — RCA 1179697-C1 Rev. E, from Arwood Corporation, Tilton, N. H.
- Storage Module Mfg. Subassembly, RCA 1753128-505 Rev. K, from Bridge Incorporated, Philadelphia, Pennsylvania.

2. Tooling

All of the GFE fabrication tools required for storage module machining have been inventoried, cataloged, photographed, and packaged for subsequent delivery to the vendors. A complete list of tooling is contained in Table 2.

TABLE 2. BATTERY MODULE TOOLING LIST

Quantity	Description	RCA Part Number
A. Tooling required to produce Battery Module No. 1173794		
1	First Operation Milling Tool	1173543-1M1
1	Second Operation Milling Tool	1173543-1M2
1	Third Operation Milling Tool	1173543-1M3
1	Fourth Operation Milling Fixture	1173543-41M4
1	Fifth Operation Milling Fixture	1173543-51M5
1	Milling Fixture 1M6	1173543-1M6
1	Milling Fixture 1M7	1173543-1M7
1	Ninth and Tenth Operation Milling Fixture	1173543-1M7
1	Drill Jig 1J1	1173543-1J1

TABLE 2. BATTERY MODULE TOOLING LIST (Continued)

Quantity	Description	RCA Part Number
1	Drill Jig 1J2	1173543-1J2
1	Drill Jig 1J3	1173543-1J3
1	Drill Jig 1J4	1173543-1J4
1	Piercing Tool 1P1 (4 pieces)	1173543-1P1
1	Piercing Tool 1P3 (2 pieces)	1173543-1P3
1	Piercing Tool 1P4 (2 Pieces)	1173543-1P4
1	Locating Block	1173543-J5
1	Milling Operation Angle Plate	----
	a. Fourth Operation, Side 1	1173543-41M4
	b. Fifth Operation, Side 2	1173543-51M5
2	Boring Tool, Rough	1173543-1Y1
2	Boring Tool, Finish	1173543-1Y2
1	Special C′ Sink	1173543-1Y3
1	Special Reamer	1173543-1Y4
1	Special C′ Bore	1173543-1Y5
1	Boring Tool 1Y6	1173543-1Y6
1	Boring Tool B	1173543-B
4	Milling Fixture Supports	NONE
B. Tooling required to produce Side Plates, No. 1755154		
1	Milling Fixture 1M1	1178581-1M1
1	Milling Fixture 1M2	1178581-1M2
1	Drill Jig (2 pieces)	1178581-1J1
1	Lathe Fixture	1178581-101
1	Special C′ Sink	1178581-1Y1
1	Straighten Fixture (and associated parts)	1178581-1A1
C. Tooling required to produce cover, No. 1755154		
1	Cover Fixture	1179168-1J1

TABLE 2. BATTERY MODULE TOOLING LIST (Continued)

Quantity	Description	RCA Part Number
D. Miscellaneous		
3	Fixtures	--------
7	Discs	--------
7	Tools	--------
NA	Hardware	--------

SECTION 5

ENGINEERING RELIABILITY

A. GENERAL

Engineering reliability provided support for the procurement and preconditioning of parts for the Nimbus-D Solar Conversion Power Supply Subsystem program. Design changes required to overcome problems encountered on the Nimbus-B program and substitution of specified parts that could not be obtained because of vendor changes were recommended.

B. SEMICONDUCTORS

1. Transistor, Type 2N491B

The approved transistor, type JAN 2N491B, manufactured by Texas Instruments, was recommended by Engineering Reliability and approved by Design Engineering. The original, type 2N491B, was no longer manufactured by the General Electric Company.

2. Diode, Type 1N4824

Diode type 1N4824 was no longer available from the Westinghouse Corporation. Engineering Reliability suggested Slator Electronics as an alternate. After a favorable survey by Field Product Assurance, parts list 1840998 was changed to reflect the new vendor source.

C. RESISTORS

Engineering Reliability granted a waiver on the preconditioning of RCA Part No. 1840389 Level I, a Ward Leonard RN Metal Film Resistor, as the vendor uses the upper limit of 175°C for temperature cycling. The specified temperature for preconditioning is 125°C.

D. CAPACITORS

Engineering Reliability investigated the effects of increased current levels on RCA part no. 1846293-1 presently used on the Nimbus-B and -D programs. Conclusions drawn from a 2000-hr life test conducted by the vendor (General Electric Co.) and conferences with the vendor and NASA indicate that the new 4-ampere limit is reasonable. However, it is recommended that higher levels (up to 5 amperes) be investigated by further tests at the part and subsystem level prior to installation.

SECTION 6

PROGRAM FOR THE NEXT REPORT PERIOD

The program quarterly report for the period of December 15, 1967 through March 15, 1968 will not be issued as a result of stop-work order listed in Section 1, Paragraph C. A program quarterly report will be issued in lieu of the report delayed by the stop-work order. This report will be issued at the end of the program and it will represent the last quarterly report.

APPENDIX I

NIMBUS-D SOLAR CELL MODULE EVALUATION PROGRAM

A. INTRODUCTION

This appendix outlines the mechanical inspection procedure, cleaning procedure, and electrical test procedure for the Nimbus-D solar cell modules which have been in storage for the past three years. The solar cell module evaluation schedule is shown on Figure I-1.

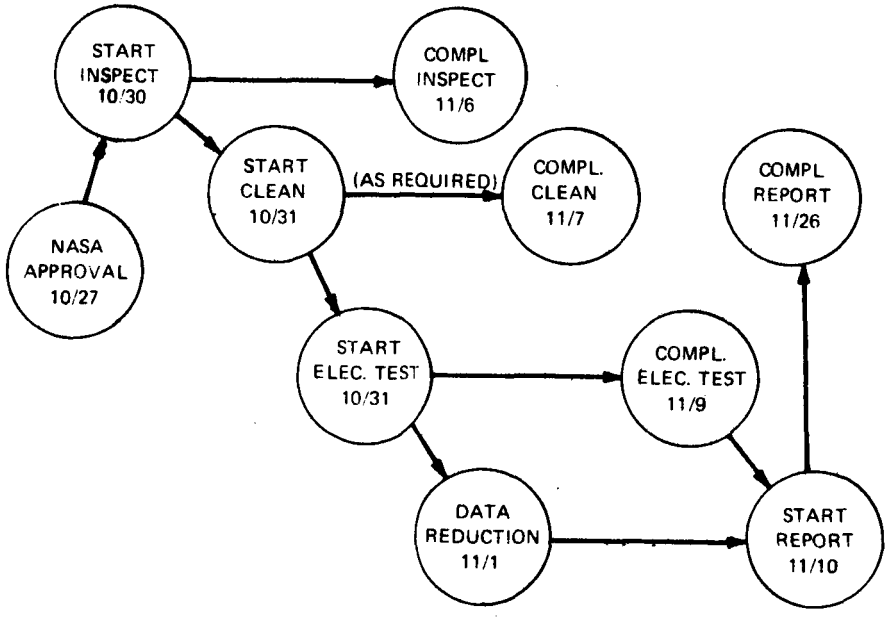

Figure I-1. Nimbus-D Solar Cell Module Evaluation Schedule

B. MECHANICAL INSPECTION PROCEDURE

The mechanical inspection for each solar cell module was performed as follows:

1. The following criteria were visually examined when the modules were unpacked.

a. Coverglass cracks
b. Cell cracks
c. Chips
d. Tab condition
e. Mechanical dimensions (GO NO-GO)

2. Discrepancies noted during visual inspection (a through d) were checked against the existing module travel tags and the additional damage was recorded on new travel tags.

3. Each module was passed through its appropriate go no-go profile gauge to verify the outline dimensions.

4. At the conclusion of each module inspection, the new travel tag was attached to the existing travel tag.

C. TAB CLEANING PROCEDURE

1. Material. The following are required to clean the solar cell tabs:

- Solution - 10% Sodium Cyanide
- pH paper - 7 to 9 range
- Distilled Water

2. Procedure

a. Place module on a flat horizontal surface so that connector strip nests on blotter paper.

b. Using a cotton swab, wet with the sodium cyanide solution, wipe the exposed surface of the copper strip until the oxide is removed.

c. Using a dry cotton swab, remove the excess solution from the surface of the copper strip. Care should be exercised to prevent the solution from wicking onto the module.

d. Remove the blotter paper and replace with fresh blotter.

e. Using distilled water and cotton swab, wipe surface of strip several times. A clean swab shall be used each time.

f. Check surface (wet) with pH paper (7 to 9 range) for any residual cleaning solution. If any material remains, repeat steps d, e, and f.

g. If test indicates the surfaces are clean, use methyl ethyl ketone and cotton swabs to wash down the treated surface.

D. ELECTRICAL TEST PROCEDURE

1. Requirements

The electrical test of modules shall be performed under a test illuminator whose calibration shall provide an intensity of 136.6 mw/cm^2 at an air mass zero (AM0) equivalent spectrum. This shall be accomplished by measuring the short circuit current of three cells whose air mass zero current has been determined by comparison to JPL balloon standards under a simulated air mass zero spectrum or sunlight illumination. Refer to Section IV of the "Nimbus-B Solar Conversion Power Supply Subsystem, Quarterly Report Number 7", (AED-R-3205) issued August 15, 1967.

2. Test Equipment Required

The test equipment listed in Table I-1 is required to perform the electrical tests of the solar cell modules.

TABLE I-1. TEST EQUIPMENT REQUIRED

Quantity	Description	Manufacturer and Part No.
1	Test stand and illuminator	RCA
1	Solar module test fixture	RCA 1754-398
2	Digital voltmeters	NLS Model 3020
1	Intensity scan probe cell (2x2 cm)	
1	Calibrated 1Ω resistor	
1	Temperature bridge	Leeds and Northrup catalog 8692
1	Electronic load	Spectrolab Model D550
1	Voltmeter	John Fluke 825 A

3. Intensity

The light source shall be tungsten filament lamps operating at 120 volts. The intensity pattern over the 10-cell module area shall be 136.6 ±2.7 mw/cm^2 as determined by the use of a calibrated standard solar cell in the manner described in Paragraphs 5 and 6.

4. Temperature

All measurements shall be made at a temperature of 25° C ±2° C. This temperature shall be determined by a thermocouple probe measurement on the top of the filter glass covering the cells.

5. Standard Cell Selection Procedure

a. Connect electronic load, module test fixture, and digital measuring equipment so as to obtain I-V curves from modules. The test circuit is shown on Figure I-2.

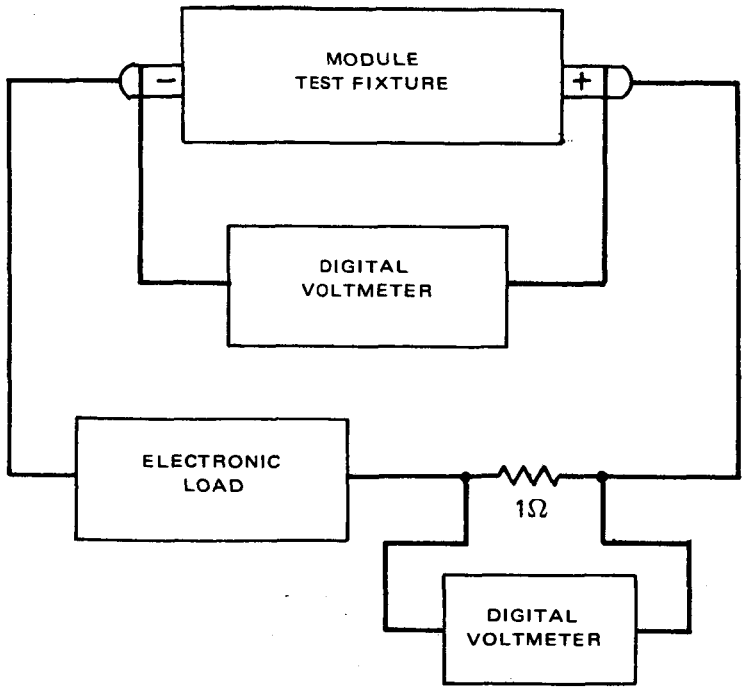

Figure I-2. Module Test Circuit

b. Connect standard cell No. 1 to 1Ω resistor across the terminals of John Fluke voltmeter. Set Fluke meter scales and sensitivity to obtain one full division equal to 0.001 volts. Set Fluke meter to standard cell's calibrated value. (AM0, 136.6 mw/cm^2).

c. Place standard No. 1 under the illuminator. Adjust intensity until AM0, 136.6 mw/cm^2 short circuit current is obtained at cell temperature of 25° C.

d. Read the short circuit currents of the remaining standard cells. Sum the total short circuit currents.

e. Place standard cell No. 2 under the illuminator and repeat steps a and b.

f. Place standard cell No. 3 under the illuminator and repeat steps a and b.

g. Select a standard cell which provides a measured short circuit sum closest to the sum of short circuit calibration values without exceeding that total, as shown by calibration criterion:

$$\sum_{N=1}^{3} I_{scm} \leq \sum_{N=1}^{3} I_{sco}$$

where,

I_{scm} is the measured short circuit current

I_{sco} is the air mass zero short circuit current (adjusted to 136.6 mw/cm^2)

h. Place the selected standard cell under the illuminator and adjust the illuminator to the standard cell's I_{sco} at 25°C. Place intensity probe cell on the 0.12 inch block, at same position, under illuminator. Record the I_{sc} at 25°C. This is the probe cell I_{sc} test value.

6. Module Test Procedure

a. Insure that all test personnel who will handle modules are wearing lab coats and finger cots.

b. Place module in position. Place probe cell in position over the module. Make cursory scan of entire module by moving the probe cell above the module surface. Adjust illuminator table to obtain approximate test value on probe cell over entire module surface.

c. Place probe cell in each of ten cell positions on module. Record short circuit current from Fluke meter with cell at 25°C. If all recorded values are within ±2 percent of calibration value, insure that no more than seven points are above or no more than seven below the probe cell test value. Adjust light uniformity and intensity to obtain this condition.

d. Place the temperature probe on each of the 10 cells in the module. Record the indications. If all temperature measurements are 25° ±2°C insure that the sum of the ten measurements is between 240 and 260°C. Adjust cooling to insure this condition.

(1) From step d, locate a single position on the module at which the temperature is 25°C. For all additional modules, measure and record the temperature at this point only. Repeat entire temperature scan (step d) every four hours of illuminator running time. The single temperature point must be 25° ±1°C.

e. Place voltage range switch (on electronic load) at 1 volt and milliamperes at 5000.

f. Place test mode switch in the V_{oc} position. Record the value in millivolts on the travel tage.

g. Place test mode switch in the V adjust position. Set the adjustment switch to 0.46 volts. Record the current on the travel tag.

h. Set the adjustment switch to 0.37 volts. Record the current on the travel tag and data sheet.

i. Set the adjustment switch to 0.27 volts. Record the current on the travel tag.

j. Repeat Steps d(1), e through i for each module to be tested. After every four hours of illuminator running time, repeat intensity and temperature recalibration, Steps 5d and 5e.

APPENDIX II

SOLAR CELL PERFORMANCE ANALYSIS

A. ABSTRACT

Solar cells obtained from vendors are tested for current at 0.33 volts, 0.42 volts, short-circuit current and open-circuit voltage. To make these readings meaningful, a simple analysis program has been written.

B. STATEMENT OF PROBLEM

The cells are received in boxes which may contain up to 350 cells, each of which is numbered (001-350). The cells are to be distributed in arbitrarily selected brackets (current or voltage) by box. The mean currents and mean open-circuit voltage and the standard deviations by manufacturer are to be calculated.

Programming was established as shown in Paragraphs C and D. A header card, to be printed at the top of each page is read out. The next card contains a set of data to be used for setting up the upper-bounds current at 0.33 volts. After the bounds have been prepared, a set of data is read out, one card per cell. In the first pass the data for 0.33 volts is distributed, while the remaining data is stored on magnetic tape for subsequent use. The distribution for 0.33 volts is printed at the end of a box and the next set of bracketed data is read and new brackets are set up. The data for this pass (0.42 volts) is read from magnetic tape. Processing is the same for the next two data sets as for the first. At the end of the run the means and standard deviations are printed.

C. INPUT PROGRAM

Card	Column	Information
1	1	1
	2-80	Title information
2	1-3	lowest bracket for 0.33 volts
	4-5	increment (Δ bracket)
	6-7	number of brackets (01-25)
3-n	1-3	cell number

Card	Column	Information
	4-8	current at 0.33 volts
	9-13	current at 0.42 volts
	14-18	short-circuit current
	19-23	open-circuit voltage
n+1	1-3	-1 for last data set 000 for end of box
n+2	1-3	lowest bracket for 0.42 volts
	4-5	Δ bracket
	6-7	number of brackets
n+3	1-3	lowest bracket for short-circuit
	4-5	Δ bracket
	6-7	number of brackets
n+4	1-3	lowest bracket for open-circuit
	4-5	Δ bracket
	6-7	number of brackets
n+4	1-3	lowest bracket for short-circuit
	4-5	Δ bracket
	6-7	number of brackets

D. OUTPUT PROGRAM

For each succeeding box the breakdown following output is printed:

Title
Subtitle
$Bracket_o + \Delta B$ $Bracket_o + 2\Delta B$. . . $Bracket_o + n\Delta B$,
where n = number of brackets

A_i A_j . . .
where A_i, j . . . are cell numbers

$Total_1$ $Total_2$ . . . $Total_n$

In addition the mean and standard deviation of each distribution is printed at the end of all data.

Although this program was written for solar cell readings analysis, it is sufficiently general to lend itself easily to many types of problems involving the distribution of data. With the addition of a small routine it will be able to handle three-dimensional distributions as well.

E. ACKNOWLEDGEMENT

The Solar Cell Performance Analysis program was developed by John Reber on February 9, 1967.

APPENDIX III

SOLAR CELL-MODULE HISTOGRAMS

Histograms for the current output at 0.27V, 0.37V, 0.46V, and the open circuit voltage (V_{oc}) of the 10-cell modules are shown in Figures III-1 through III-4, respectively. Each histogram lists the modules in columns representing 4-ma or 2-volt brackets. The second digit of each box number in which the module is currently stored precedes the module number. Since the data is plotted sequentially, it is possible to determine the box numbers by their relative position on the histogram. For example, on Figure III-1 there are 74 modules listed in the 1330-ma column; entry 12089 refers to module 2089 in box number 1, entry 12060 (35 positions lower) refers to module 2060 in box number 11.

Histograms of the six-cell modules are shown on Figures III-5 through III-8.

1294	1298	1302	1306	1310	1314	1318	1322	1326	1330	1334	1338	1342	1346	1350	1354	1358	1362	1366	1370
11894	11121	12135	12146	10541	10389	10525	12102	12099	12089	12088	10013	11974	22118	12110	21679	20162	30881	30144	22215
12046	10822	11789	11935	11921	10488	11884	11778	10196	21963	11996	12095	21255	32120	30004	22125	20015	31473	41571	31459
10396	11397	12068	11726	11941	22191	12006	11837	21536	21421	12098	12282	20068	31102	41642	31469	32084	41618	82139	41677
11864	11975	12179	11512	11994	21563	11715	11564	22121	22133	20199	10329	20155	32119	41654	31670	31455	50384	81962	41211
11705	11628	10349	12043	11936	21589	21820	22063	21422	21672	21013	21956	21663	32005	41454	41666	41524	91686	81682	81681
11991	11630	41465	21928	11424	21862	22116	21895	20921	31938	20111	21525	21694	41493	41403	51688	41738	51457	60023	52251
11436	21409	72165	31337	11992	31443	20122	22127	21416	31464	21458	31496	32100	41185	51826	51964	80087	52245	60167	60164
21515	71400	91387	31472	21848	31351	21769	20494	31249	32056	21583	30506	31307	41266	51822	61979	52250	52263	72107	60166
21940	81635	92156	80913	21349	51951	20890	20093	32022	32094	30038	30903	31691	41835	51764	61634	72105	71950	72101	72104
31508	91786	1771	81551	31653	71562	31594	22093	31135	41567	31625	30201	31468	51875	51952	61949	71685	71540	82111	81218
71388	2207	2078	2162	31417	71747	41444	21297	41427	41656	30026	31976	30699	51954	51749	70362	71157	81196	80006	0
71326	1787	2002	2227	32025	81852	41245	21674	41623	41322	31353	30435	31471	51967	51772	71516	80542	80206	81232	0
71328	80	11776	2024	41660	81721	41576	31897	41407	41648	31695	31467	31631	51729	61792	80168	10157	82104	0	0
81385	12073	12020	2196	51373	81482	51748	31466	40606	41438	31194	31644	41693	61815	61526	81980	0	81347	0	0
1850	11756	11375	1876	61823	91881	51927	41596	41415	41450	41657	41692	41651	61920	61605	82040	0	1961	0	0
1966	11770	11990	2058	71384	92015	51923	41668	51791	41414	41166	41501	41401	61542	61575	82032	0	1052	0	0
1248	11730	11767	2081	71327	276	61807	41502	51659	51854	41405	41494	41676	61566	61462	91689	0	2092	0	0
2135	11888	21658	405	80917	2196	61486	41449	51743	51916	40537	41333	51828	61504	80808	91904	0	813	0	0
12009	11773	21710	12008	81922	1800	70957	41323	51919	51912	51796	41664	51816	61521	80205	52258	0	0	0	0
12018	11708	21933	12140	91622	1906	72168	41396	51978	51969	51836	51813	51839	70237	143	52243	0	0	0	0
11915	20769	22029	12114	91372	820	71599	51833	51926	61537	51981	51774	51971	71522	2129	52262	0	0	0	0
10950	21913	21970	11568	91917	10180	82148	61832	51982	61376	61873	50108	51817	71534	163	52246	0	0	0	0
11716	21728	21745	12072	90491	11523	82164	61872	61853	71500	61914	51908	51840	80051	20940	52248	0	0	0	0
11737	20071	21940	12031	90037	11797	91947	61590	61740	71510	61557	51855	51819	80102	52261	62154	0	0	0	0
11883	20077	30434	11702	92208	21861	90097	61474	61514	71570	71579	51924	51662	81684	51803	61595	0	0	0	0
11655	31370	31805	11783	425	22126	2158	61529	61574	71402	71555	51763	51492	82042	52175	71892	0	0	0	0
22077	31528	31311	21703	2220	32239	2193	61639	61506	70605	71484	51762	61842	91798	51205	71461	0	0	0	0
21896	32011	31960	22039	1096	31082	269	61453	61610	81593	70841	61824	61753	92076	52242	81344	0	0	0	0
21567	31448	42007	21788	11775	30455	2188	61572	61485	81885	72173	61475	61814	92064	62265	80358	0	0	0	0
21723	32057	42001	22131	12122	32013	1765	61538	61548	82034	71809	61498	61552	90133	62161	81973	0	0	0	0
21720	31124	42016	20052	11661	31272	2004	61477	61641	91718	72167	61847	70785	91918	62037	1680	0	0	0	0
21704	31793	42219	21945	11856	40909	1777	71483	70523	91617	71004	61517	71011	92054	72027	0	0	0	0	0
21620	31925	41802	21007	11696	41412	2044	71447	71613	90065	82124	71479	80849	92216	72130	0	0	0	0	0
21830	41238	52021	20073	12030	41985	1886	71330	71024	91890	81699	71520	81597	91678	70232	0	0	0	0	0
20011	41378	51432	21638	12080	41984	11115	72163	72172	1857	91675	71629	81503	90003	71201	0	0	0	0	0
22141	91488	91561	31545	22035	42109	11860	71533	80027	12060	92000	71603	81766	20165	71413	0	0	0	0	0
31619	0	1303	31972	20040	42112	12132	72174	80500	10001	2195	71478	91588	20088	80289	0	0	0	0	0
31645	0	0	41989	31470	41988	10550	71768	81549	40005	2214	71003	91601	42267	80292	0	0	0	0	0
31550	0	0	42041	31558	42281	12052	81757	81600	42268	1275	70963	91821	42247	91048	0	0	0	0	0
31948	0	0	42270	31519	41761	11712	81607	81711	52234	21683	70521	2108	52237	91476	0	0	0	0	0
31382	0	0	40074	32255	52190	11878	81795	91633	52038	22128	80235	32253	62166	0	0	0	0	0	0
31383	0	0	50147	30543	62223	20245	81556	92059	52151	31532	82179	52236	62051	0	0	0	0	0	0
31342	0	0	51380	31243	60254	22145	81898	92232	51804	31586	81673	50178	61581	0	0	0	0	0	0
31332	0	0	61801	31251	61734	20002	81598	92023	52244	42223	81733	51999	61997	0	0	0	0	0	0
41958	0	0	61209	31965	81398	32010	91573	92045	52256	40800	91882	52228	82017	0	0	0	0	0	0
41901	0	0	91900	40354	90294	31602	91911	2066	61932	42284	92082	50892	90255	0	0	0	0	0	0
41879	0	0	91874	40034	91611	31955	91939	1754	62136	52249	91615	62274	91592	0	0	0	0	0	0
41760	0	0	91591	40075	91391	32096	91858	12075	61713	50623	91887	62238	90085	0	0	0	0	0	0
50629	0	0	1880	42259	1759	40195	952	21697	62061	52152	91827	62083	1531	0	0	0	0	0	0
91325	0	0	0	40529	1909	42229	2153	21544	62012	52257	92019	62115	1511	0	0	0	0	0	0
1585	0	0	0	41977	318	42235	2224	21931	71983	52157	92103	60086	1513	0	0	0	0	0	0
0	0	0	0	40033	1719	42213	1509	22137	71652	61893	92231	61709	882	0	0	0	0	0	0
0	0	0	0	50061	1578	50045	10466	31934	70050	62144	2147	62036	0	0	0	0	0	0	0
0	0	0	0	91899	11302	51309	12143	31195	71559	61871	21785	72048	0	0	0	0	0	0	0
0	0	0	0	91843	11564	62047	21582	31998	71987	61717	41009	70041	0	0	0	0	0	0	0
0	0	0	0	31	11725	62077	22138	30509	71352	72090	52160	71790	0	0	0	0	0	0	0
0	0	0	0	1423	11752	61665	32142	30211	71866	72014	50067	71794	0	0	0	0	0	0	0
0	0	0	0	1649	11746	71714	32159	42276	81889	71838	62155	70059	0	0	0	0	0	0	0
0	0	0	0	0	0	71758	32097	42252	81127	71587	61495	70088	0	0	0	0	0	0	0
0	0	0	0	0	0	81404	31410	40626	81364	70874	62149	81155	0	0	0	0	0	0	0
0	0	0	0	0	0	81810	42055	42280	81986	71706	61627	82087	0	0	0	0	0	0	0
0	0	0	0	0	0	91671	42285	42279	81497	71604	61831	82091	0	0	0	0	0	0	0
0	0	0	0	0	0	91637	41865	52277	81491	72117	62050	81616	0	0	0	0	0	0	0
0	0	0	0	0	0	90058	51530	52286	81518	72074	71295	80189	0	0	0	0	0	0	0
0	0	0	0	0	0	1700	52271	52217	90773	71698	71640	80906	0	0	0	0	0	0	0
0	0	0	0	0	0	1751	62178	51905	91841	81261	72065	80204	0	0	0	0	0	0	0
0	0	0	0	0	0	1374	61707	51614	91845	91565	71744	80599	0	0	0	0	0	0	0
0	0	0	0	0	0	11463	71799	60072	91560	91644	71731	80109	0	0	0	0	0	0	0
0	0	0	0	0	0	0	70082	62026	91539	90977	80376	91869	0	0	0	0	0	0	0
0	0	0	0	0	0	0	71846	60069	91546	91870	80899	91606	0	0	0	0	0	0	0
0	0	0	0	0	0	0	70039	62106	1727	1698	81093	90927	0	0	0	0	0	0	0
0	0	0	0	0	0	0	80024	62070	2067	1735	80236	91481	0	0	0	0	0	0	0
0	0	0	0	0	0	0	81621	71736	2033	1742	81543	91825	0	0	0	0	0	0	0
0	0	0	0	0	0	0	81259	71722	1460	1128	80680	90233	0	0	0	0	0	0	0
0	0	0	0	0	0	0	81646	71626	0	1829	80188	91487	0	0	0	0	0	0	0
0	0	0	0	0	0	0	80369	80242	0	1489	81944	1993	0	0	0	0	0	0	0
0	0	0	0	0	0	0	91780	81624	0	11741	91782	1687	0	0	0	0	0	0	0
0	0	0	0	0	0	0	91812	91418	0	11577	92028	1690	0	0	0	0	0	0	0
0	0	0	0	0	0	0	91851	91910	0	0	2053	1180	0	0	0	0	0	0	0
0	0	0	0	0	0	0	91865	91781	0	0	8	57	0	0	0	0	0	0	0
0	0	0	0	0	0	0	91554	91527	0	0	1480	11650	0	0	0	0	0	0	0
0	0	0	0	0	0	0	91806	91784	0	0	1609	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	2003	91902	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	1505	91636	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	1612	1701	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	1739	1304	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	11755	1569	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	11750	1315	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	11406	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	11547	0	0	0	0	0	0	0	0	0	0	0
51	36	37	49	58	58	68	88	90	74	78	82	81	52	40	31	13	18	12	10

III 2-A

Figure III-1. Nimbus-D, 10-Cell Module Histogram, Current at 0.27 Volts

																			1318	1342	1346
																			11974	12110	31459
11894	11864	31508	11397	12135	11941	11837	12006	10196	12102	12089	21956	12282	21255	21694	21679	31670	30881	50384	41677		
12046	11436	71326	12146	10389	11884	10488	11715	10013	21013	12098	22133	21525	20155	32084	22125	41403	31473	82139	81962		
[illegible]					11996																
[illegible]					11924																
11991	41465	12073	31653	12068	11726	20890	22116	22063	21458	21536	30903	31468	32120	32005	41654	81980	41618	82104	60164		
1850	71388	12009	71400	12179	11512	21589	21769	21895	22093	20068	30201	30699	31307	31631	41454	52250	41211	81232	72107		
1248	71328	11919	80917	11630	11992	21862	20093	21422	21672	20494	31976	31471	30144	41642	51688	52243	81964	0	72104		
10950	81369	11780	91387	32025	12043	21848	21297	20921	21416	21421	31695	31467	31102	41666	51952	51457	81682	0	81318		
11716	80	11888	92156	61823	21928	41660	31443	21583	31249	20111	41657	31644	32094	41493	51749	52245	91689	0	1961		
11937	11375	21896	91786	72165	22191	51373	41494	21674	31194	30038	41692	41166	41501	41835	51729	62154	52263	0	0		
11883	21723	20769	1771	80913	21349	70957	41245	31351	41427	31938	41450	41266	41185	51822	61979	60167	60023	0	0		
11695	21907	21913	2207	90491	21417	71747	40606	31897	41668	31625	41405	41664	41693	51764	61920	71950	72105	0	0		
22077	20077	20071	1966	2162	31337	81852	41576	31594	41502	31464	51796	51826	41651	51967	61575	71157	71461	0	0		
21567	31619	31645	2135	2024	31472	80027	51951	41596	41407	32056	51908	51828	41401	51971	61462	81196	72101	0	0		
21720	31470	31124	11756	2058	71384	82148	61610	41444	41449	32022	51912	51813	41676	51817	80087	80206	82111	0	0		
21830	31382	31793	12020	2078	71327	81551	71562	41322	41396	31135	51969	51774	51875	51772	80808	80292	80096	0	0		
20011	31342	31311	11770	2002	71024	81922	82164	41323	51791	31466	61824	51816	51954	61753	80102	80542	0	0	0		
22141	41378	31925	11990	405	81549	81721	81795	51833	51659	31353	61914	50108	51855	61542	82040	1052	0	0	0		
20434	41760	41238	11767	1096	91881	81482	91372	51748	51743	30435	61498	51839	51763	61504	82032	2092	0	0	0		
20820	40147	40074	11773	11776	90097	91622	92015	51919	51923	41667	61847	51924	51840	61526	91904	813	0	0	0		
31948	0	61209	11708	12008	2227	91917	2158	51927	61832	41623	61517	51762	51819	61605	52261	10157	0	0	0		
31383	0	0	11783	12140	276	90037	2193	61807	61514	41656	71579	51492	51662	61521	52258	0	0	0	0		
31332	0	0	21658	12114	425	92208	2196	61590	61474	41648	71500	61873	61792	70362	51803	0	0	0	0		
41879	0	0	21728	11568	2220	952	2153	61529	61537	41438	71520	61842	61814	71916	52262	0	0	0	0		
50629	0	0	21710	12072	2196	2004	269	61486	61574	41333	71484	61552	61815	71603	52246	0	0	0	0		
91325	0	0	21861	11702	1876	1800	2188	61548	61639	41415	71629	61557	61566	71534	52248	0	0	0	0		
0	0	0	21704	21703	2081	1777	1509	71483	61376	41414	71478	70785	61475	80168	62037	0	0	0	0		
0	0	0	21788	22039	11115	1906	1886	71447	61506	40537	72173	70521	70237	80205	72027	0	0	0	0		
0	0	0	21620	22131	11775	820	21697	72168	61453	51854	71003	80051	80235	91798	71892	0	0	0	0		
0	0	0	20052	22029	12122	11860	31955	72163	61572	51836	70963	82179	81503	92076	72130	0	0	0	0		
0	0	0	21745	21970	12018	12132	31195	71599	61538	51981	80849	81597	82042	91686	70232	0	0	0	0		
0	0	0	20040	21945	11561	10550	32097	72174	61477	51916	82124	81673	92082	90133	71201	0	0	0	0		
0	0	0	31805	21940	11356	12052	32013	81757	70523	51978	81593	81733	92064	91918	81344	0	0	0	0		
0	0	0	31370	20073	10180	12030	31410	81556	71570	51926	81684	91882	91821	92054	80289	0	0	0	0		
0	0	0	31528	30543	11596	11712	32096	91718	71330	51982	81699	91615	2129	92216	80358	0	0	0	0		
0	0	0	32011	31243	11523	10466	42055	91858	72172	61872	82034	91601	163	20940	81973	0	0	0	0		
0	0	0	31448	31082	12031	20245	42229	2224	71011	61853	91887	92019	21785	52175	81347	0	0	0	0		
0	0	0	32057	30455	12080	32239	42281	1765	71533	61740	91588	92103	42247	51999	91476	0	0	0	0		
0	0	0	31251	42016	11978	32010	42213	2044	71004	61485	92000	91678	52236	52237	0	0	0	0	0		
0	0	0	31960	40354	11797	31519	62223	1754	71768	61641	91827	2147	51205	52242	0	0	0	0	0		
0	0	0	41958	52021	22035	32255	71722	10001	70605	71479	92231	31532	62238	62265	0	0	0	0	0		
0	0	0	42007	50045	21933	41412	70082	12143	81607	71613	90003	32253	62083	62166	0	0	0	0	0		
0	0	0	41901	50061	22145	40195	70039	22138	81898	71510	2108	42267	62051	62161	0	0	0	0	0		
0	0	0	[illegible]																		

III-3 A

Figure III-2. Nimbus-D, 10-Cell Module Histogram, Current at 0.37 Volts

1184	1188	1192	1196	1200	1204	1208	1212	1216	1220	1224	1228	1232	1236	1240	1244	1248	1252	1256	1260
10822	11121	12046	11894	12099	11028	11921	11935	11397	12088	10525	11975	11936	12089	20494	12102	32119	51688	51749	31459
10541	10396	20122	12146	11941	21058	12110	11837	11994	12282	11996	12095	11974	20162	20015	20155	41651	51964	91947	51971
10013	11884	20093	11864	11705	30088	12179	10488	11424	12068	12135	12098	21525	21663	21679	21694	41401	51729	52243	81962
10349	10389	41465	11991	10196	32025	20199	11992	11564	11512	11789	12006	21674	22093	22133	30506	41835	51924	51803	81681
71024	41494	71327	21013	10329	31608	21963	12043	11436	11630	11778	11715	21416	22118	22125	31307	51969	51817	72027	91689
71011	70957	425	80917	20068	61023	22191	21536	21422	21928	21956	11726	31496	32120	31467	30144	61634	61575	82091	71461
143	90491	1275	90003	21515	71003	21589	21409	20111	21255	21421	22063	32100	31691	31670	31631	82032	52244	81232	71540
80	90097	11783	1248	20890	81535	21297	21349	20921	21820	31443	21895	31351	31464	32005	41501	91372	52157	11547	1961
11375	952	20088	1857	21862	11350	21583	31135	31938	22116	31625	22127	31249	32056	31695	41623	91573	61627	0	0
10950	11860	31470	1787	71328	21220	31653	41245	31417	22121	41185	22215	30881	32022	41642	41738	21582	71714	0	0
20769	11878	0	1096	71004	11336	31194	40606	30004	21769	41322	21940	31976	32094	41692	41454	52262	72105	0	0
21723	21720	0	10001	80027	605	40537	61514	31337	21563	41266	32084	41596	31471	41166	51952	52160	71652	0	0
21861	20052	0	10550	81549	11775	51826	61610	30435	21848	41414	31468	41654	31469	41656	51840	52251	72107	0	0
20011	22141	0	11716	276	12073	81852	71516	41657	21672	41576	30026	41677	31473	41493	51819	52152	80292	0	0
22145	20071	0	11883	1509	11356	80849	71522	72172	31455	51836	30903	41211	31644	41502	51662	52245	91592	0	0
21007	31082	0	11888	11115	12030	1771	71384	70963	30699	61590	31102	51875	41427	41693	61872	62166	0	0	0
20002	42229	0	10466	10180	11737	2214	71400	71326	31897	61526	31472	51822	41668	41618	61753	60164	0	0	0
20077	91325	0	22077	11702	11555	1754	71388	70605	30201	61517	31594	51659	41571	41450	61949	62050	0	0	0
20040	91780	0	21830	11773	21896	11776	71747	82148	31466	61548	41444	51764	41657	41664	61920	61734	0	0	0
30434	0	0	20073	11797	21567	11770	80051	90065	31353	71555	41660	51916	41524	41403	61740	72048	0	0	0
31948	0	0	31382	21703	20165	12052	81757	91786	41666	71629	41438	51927	41648	41396	61504	70232	0	0	0
31311	0	0	30543	21697	21745	11523	80913	2153	41333	72165	41405	51926	41407	51854	61557	71758	0	0	0
31251	0	0	30455	20245	21940	12072	81385	2196	41415	71599	51774	51855	41676	51816	71534	82017	0	0	0
31383	0	0	31332	22126	21638	12080	81721	269	41323	72167	51833	51762	41449	51981	82139	82104	0	0	0
40354	0	0	41009	31550	31528	11712	91675	2108	50108	72174	51373	61792	51828	51978	82040	0	0	0	0
41378	0	0	42235	31243	32010	11990	91718	2224	61824	81684	51919	61542	51813	51967	81682	0	0	0	0
40034	0	0	40529	31124	31519	11767	91387	2081	61529	81482	61807	61376	51839	51912	81711	0	0	0	0
40075	0	0	61209	31342	31602	21658	90037	2004	70523	91633	61537	61498	51791	51982	92064	0	0	0	0
40626	0	0	70082	30211	31195	21728	92231	2129	71447	91858	61574	61641	51796	51763	51905	0	0	0	0
40005	0	0	0	31272	31410	22039	1876	1906	71520	92232	61639	71479	51748	51772	51999	0	0	0	0
41879	0	0	0	41238	31925	21710	2058	11756	70362	2044	61486	71613	51951	51492	52257	0	0	0	0
40074	0	0	0	41985	40909	21788	2066	12132	70841	12075	61485	71562	51743	61873	62037	0	0	0	0
40033	0	0	0	42112	42219	21620	1800	12009	72168	31370	71510	70785	51954	61832	62036	0	0	0	0
50147	0	0	0	42041	41760	21945	1777	12018	72163	32255	71483	72173	51908	61842	62012	0	0	0	0

III 4A

Figure III-3. Nimbus-D, 10-Cell Module Histogram, Current at 0.46 Volts

589	590	591	592	593	594	595	596	597	598	599	600	601	602	603
20068	12110	10541	10884	10525	21013	11121	11941	11894	12088	11397	11996	11975	12102	11936
20122	10013	10196	10389	10822	22215	12146	12282	12046	11994	11921	12089	12095	21928	11726
20093	30038	21458	10329	10396	21862	11864	10488	12099	12098	12135	11715	12006	31472	31464
30435	30201	30004	10349	21255	21525	11512	11564	11705	11630	11991	22063	11778	41692	51971
41667	71011	31508	10515	20162	20015	20199	21536	11974	21895	11424	32120	11837	41501	71570
70957	80849	41666	10468	20111	32084	21409	20494	11935	22116	11789	41623	12068	41651	81597
71004	80027	40537	10185	20921	31625	31496	21422	11628	21956	22191	41444	21820	51816	31448
10950	81757	70362	10494	20155	31469	30506	21421	12179	21589	21769	41502	22121	81681	52244
20011	90097	71003	10606	30026	31670	31353	20890	11992	21848	21663	41693	31691	82042	52160
20077	90003	2214	10237	30881	41668	31194	21297	11436	21583	22093	41450	32022	92156	52152
20040	1787	143	10484	30699	41738	41524	21672	12043	21679	21349	41405	31467	2227	0
31251	22145	10550	10629	31102	41403	41266	31653	22127	21674	22133	41407	41835	1966	0
40626	20073	11856	10516	31135	41211	51826	31938	21963	31307	22125	41664	51828	11767	0
40074	30211	10466	10841	31459	51762	51764	30903	21563	31249	21416	41576	51854	31998	0
40033	41009	21861	11024	41166	61792	51855	32025	21940	32056	21694	51875	51916	52262	0
50061	40034	20052	11852	41654	61517	61807	31337	22118	31471	31443	51796	51927	52257	0
70050	40529	20002	10051	61526	70523	61824	32094	32100	31466	30144	51688	51492	62061	0
81218	40005	42016	10808	61485	71522	61590	31594	31455	32005	31897	51748	61376	2033	0
80599	50178	40354	10913	71520	71330	61514	31631	31417	41642	31976	51952	82124	1569	0
90255	70041	42229	11675	70963	70785	61529	41427	31351	41465	32119	51981	81593	11750	0
90058	71295	40075	10133	70605	71599	61521	41245	31473	41571	31695	51951	81684	0	0
0	70082	41761	425	81673	80917	61498	41676	31644	41322	41596	51908	81598	0	0
0	70874	50629	80	90065	81962	61641	41415	41493	41438	41657	51969	81682	0	0
0	80206	50045	405	91858	80102	71555	41323	41648	41454	41660	61872	81482	0	0
0	82111	50892	11783	90037	81549	72168	50108	41618	41414	41656	61814	82034	0	0
0	80906	70088	21723	952	81733	71809	51836	41677	41396	41401	61920	91372	0	0
0	80204	80292	20165	2135	91718	72172	51840	41449	51839	41333	61853	91881	0	0
0	80109	80376	20071	11115	91615	70521	50384	51822	51659	51791	61506	92064	0	0
0	91048	80006	30434	11375	90491	71747	61823	51813	51373	51978	71579	92000	0	0
0	90294	81093	32142	20769	92054	80087	61873	51774	51919	51954	71500	92019	0	0
0	90977	81497	31602	21544	276	80500	61572	51833	51912	51749	81551	91786	0	0
0	0	90773	42223	20940	1275	91689	61610	51743	51926	51729	81922	2188	0	0
0	0	91671	50623	21007	1509	91573	71483	51967	51964	51924	81795	11756	0	0
0	0	91780	60072	22126	1857	92231	71562	51763	51982	51817	82040	21697	0	0
0	0	90085	60086	20088	1096	1248	71327	51772	51923	61832	81503	22035	0	0
0	0	31	60069	31528	11860	1765	72163	51662	51819	61842	81885	42280	0	0
0	0	1690	31157	31382	10180	2147	71533	61914	61979	61504	81711	52190	0	0
0	0	11302	80289	31311	11773	820	71326	61815	61634	61486	91617	52157	0	0
0	0	0	81347	31383	21703	10001	72167	61537	61753	61847	91939	62166	0	0
0	0	0	80242	40909	21720	12140	71328	61542	61949	61548	91601	61871	0	0
0	0	0	80236	42284	20245	11702	71768	61574	61740	61557	92059	62047	0	0
0	0	0	80369	52249	22141	12143	81980	61639	61474	71479	92045	62077	0	0
0	0	0	91644	52236	21745	21830	81385	61605	61566	71478	2196	62070	0	0
0	0	0	91527	70059	32253	22138	82148	61538	61453	71384	2224	61627	0	0
0	0	0	1680	71201	31558	32239	80205	61575	61552	71402	2058	71790	0	0
0	0	0	0	71559	31519	30543	81556	61477	61475	80168	2081	91865	0	0
0	0	0	0	70039	31948	31082	81635	71613	61462	82179	2004	1609	0	0
0	0	0	0	80358	30455	31342	92082	71510	71603	81607	12008	11547	0	0
0	0	0	0	80542	31124	31410	91588	71447	71388	81898	12114	0	0	0
0	0	0	0	90927	31272	40195	91686	71534	82164	82032	11696	0	0	0
0	0	0	0	91481	41412	41378	91918	72165	81699	91882	12080	0	0	0
0	0	0	0	91784	42112	42219	91827	71400	91622	91887	11883	0	0	0
0	0	0	0	1052	41802	42041	91890	72173	91798	91911	21913	0	0	0
0	0	0	0	1304	42285	42270	92103	72174	91917	92015	31619	0	0	0
0	0	0	0	0	42235	41977	91678	82139	91387	92232	31370	0	0	0
0	0	0	0	0	42252	42247	2220	80235	91821	2162	32159	0	0	0
0	0	0	0	0	41879	50067	269	81721	91947	2158	31965	0	0	0
0	0	0	0	0	40800	51205	1777	81600	92023	2193	31960	0	0	0
0	0	0	0	0	42268	61893	2129	81766	92208	2195	41958	0	0	0
0	0	0	0	0	50147	61801	1886	91633	1771	2207	42007	0	0	0
0	0	0	0	0	51380	71799	2078	91904	2153	2024	52250	0	0	0
0	0	0	0	0	52038	72048	1754	92076	2066	2108	51804	0	0	0
0	0	0	0	0	51614	71685	163	92216	11776	1876	51905	0	0	0
0	0	0	0	0	71722	70232	11775	2196	12020	2044	52251	0	0	0
0	0	0	0	0	72184	71604	12132	1850	11661	1906	52245	0	0	0
0	0	0	0	0	71866	80024	11712	1800	11770	12122	52242	0	0	0
0	0	0	0	0	71744	82087	11878	2002	12052	12060	62155	0	0	0

0	0	0	0	0	72101	81364	22039	12073	11568	12009	62223	0	0	0
0	0	0	0	0	81344	80899	21704	11915	12072	12018	62274	0	0	0
0	0	0	0	0	81616	91781	21970	11730	11716	12075	62144	0	0	0
0	0	0	0	0	80189	91561	21945	12030	11737	11523	61932	0	0	0
0	0	0	0	0	81491	91539	21638	11990	11888	12031	62106	0	0	0
0	0	0	0	0	80188	92028	31532	11708	11655	21896	61707	0	0	0
0	0	0	0	0	81944	91806	31550	11797	22077	21582	62050	0	0	0
0	0	0	0	0	91325	8	31545	21785	21658	21728	72027	0	0	0
0	0	0	0	0	91606	1374	31243	22131	21567	21710	71714	0	0	0
0	0	0	0	0	91487	57	31195	22128	21683	21620	71794	0	0	0
0	0	0	0	0	1961	1719	31793	21933	21788	31805	71987	0	0	0
0	0	0	0	0	1315	1460	32013	21931	22029	31925	81973	0	0	0
0	0	0	0	0	0	10157	31332	22137	31645	41985	81398	0	0	0
0	0	0	0	0	0	11725	32096	21940	31470	42259	91592	0	0	0
0	0	0	0	0	0	11577	41238	31934	32010	41760	91611	0	0	0
0	0	0	0	0	0	0	42109	31955	32255	52258	91825	0	0	0
0	0	0	0	0	0	0	42267	32097	31586	52243	1531	0	0	0
0	0	0	0	0	0	0	52277	32011	31972	52151	1700	0	0	0
0	0	0	0	0	0	0	51803	30509	41901	52256	1585	0	0	0
0	0	0	0	0	0	0	52175	32057	41984	52246	1649	0	0	0
0	0	0	0	0	0	0	51309	42055	42001	52248	0	0	0	0
0	0	0	0	0	0	0	60254	42276	41989	62026	0	0	0	0
0	0	0	0	0	0	0	61595	41865	41988	62115	0	0	0	0
0	0	0	0	0	0	0	61209	52234	42281	62036	0	0	0	0
0	0	0	0	0	0	0	61831	51457	42213	61734	0	0	0	0
0	0	0	0	0	0	0	61665	52228	42279	71983	0	0	0	0
0	0	0	0	0	0	0	72090	52263	52286	71838	0	0	0	0
0	0	0	0	0	0	0	71892	62154	52021	71587	0	0	0	0
0	0	0	0	0	0	0	72105	62265	52261	71706	0	0	0	0
0	0	0	0	0	0	0	71736	62083	51432	72074	0	0	0	0
0	0	0	0	0	0	0	72130	62161	52217	82091	0	0	0	0
0	0	0	0	0	0	0	71461	60164	51530	81986	0	0	0	0
0	0	0	0	0	0	0	71626	62149	51999	81259	0	0	0	0
0	0	0	0	0	0	0	71698	60166	52271	81404	0	0	0	0
0	0	0	0	0	0	0	81889	62136	52237	81624	0	0	0	0
0	0	0	0	0	0	0	81155	61713	60023	81261	0	0	0	0
0	0	0	0	0	0	0	81127	61717	61495	81810	0	0	0	0
0	0	0	0	0	0	0	82104	72014	62238	91869	0	0	0	0
0	0	0	0	0	0	0	81543	71652	60167	91637	0	0	0	0
0	0	0	0	0	0	0	91418	71640	62178	91476	0	0	0	0
0	0	0	0	0	0	0	91910	72065	62051	91841	0	0	0	0
0	0	0	0	0	0	0	91812	71758	62037	91782	0	0	0	0
0	0	0	0	0	0	0	91546	72117	61709	91845	0	0	0	0
0	0	0	0	0	0	0	1687	71413	61581	91899	0	0	0	0
0	0	0	0	0	0	0	1701	81621	62012	91902	0	0	0	0
0	0	0	0	0	0	0	1128	82017	61997	91636	0	0	0	0
0	0	0	0	0	0	0	1829	81518	72107	91870	0	0	0	0
0	0	0	0	0	0	0	2092	81646	71846	91874	0	0	0	0
0	0	0	0	0	0	0	1180	80680	71950	2053	0	0	0	0
0	0	0	0	0	0	0	1612	91488	71540	1698	0	0	0	0
0	0	0	0	0	0	0	1739	91560	71352	1735	0	0	0	0
0	0	0	0	0	0	0	813	90233	71731	1759	0	0	0	0
0	0	0	0	0	0	0	0	91391	81196	1751	0	0	0	0
0	0	0	0	0	0	0	0	91591	81232	1578	0	0	0	0
0	0	0	0	0	0	0	0	1727	91565	11463	0	0	0	0
0	0	0	0	0	0	0	0	1993	91900	11752	0	0	0	0
0	0	0	0	0	0	0	0	1742	91851	11746	0	0	0	0
0	0	0	0	0	0	0	0	1480	91554	0	0	0	0	0
0	0	0	0	0	0	0	0	1880	91843	0	0	0	0	0
0	0	0	0	0	0	0	0	1909	2067	0	0	0	0	0
0	0	0	0	0	0	0	0	318	2003	0	0	0	0	0
0	0	0	0	0	0	0	0	1505	1489	0	0	0	0	0
0	0	0	0	0	0	0	0	1303	1423	0	0	0	0	0
0	0	0	0	0	0	0	0	11755	1511	0	0	0	0	0
0	0	0	0	0	0	0	0	0	1513	0	0	0	0	0
0	0	0	0	0	0	0	0	0	882	0	0	0	0	0
0	0	0	0	0	0	0	0	0	11406	0	0	0	0	0
0	0	0	0	0	0	0	0	0	11564	0	0	0	0	0
0	0	0	0	0	0	0	0	0	11650	0	0	0	0	0
0	0	0	0	0	0	0	0	0	11741	0	0	0	0	0
21	31	38	45	54	79	82	119	131	137	124	87	48	20	10

Figure III-4. Nimbus-D 10-Cell Module Histogram, Open Circuit Voltage

780	784	788	792	796	800	804	808	812	816	820	824	828	832	836
40389	50359	40358	40276	40171	40327	40236	40074	40323	40221	40228	40297	40186	40328	0
50356	50360	50250	40243	40314	40232	40325	40271	40193	40302	40308	40102	40191	40246	0
60436	0	50247	50353	40318	40317	40313	40128	40281	40226	40035	40272	60424	50167	0
60431	0	70391	50388	40254	40311	40267	40319	40229	40316	40187	50335	0	60113	0
0	0	70452	60440	40315	50270	40244	40235	40320	40301	50294	50309	0	70049	0
0	0	0	60437	50332	50331	50393	40284	40278	40081	50346	60202	0	0	0
0	0	0	70432	50366	50339	50225	40343	40326	50344	50261	0	0	0	0
0	0	0	70394	50382	50361	60414	50324	40198	50194	60041	0	0	0	0
0	0	0	70364	50370	50224	60438	50340	50357	60205	60398	0	0	0	0
0	0	0	0	50383	50249	60022	50349	50336	60165	70322	0	0	0	0
0	0	0	0	50386	50296	60422	50348	50354	60136	0	0	0	0	0
0	0	0	0	50454	50099	60351	50125	50268	60403	0	0	0	0	0
0	0	0	0	60443	50156	60461	50347	50032	60300	0	0	0	0	0
0	0	0	0	60451	50195	60435	50355	50408	60450	0	0	0	0	0
0	0	0	0	70392	60365	70100	50020	50201	60407	0	0	0	0	0
0	0	0	0	70017	60350	70416	60406	50185	70050	0	0	0	0	0
0	0	0	0	70434	60378	70368	60151	60341	0	0	0	0	0	0
0	0	0	0	0	60379	70423	60015	60082	0	0	0	0	0	0
0	0	0	0	0	60345	70295	60307	60184	0	0	0	0	0	0
0	0	0	0	0	70450	0	60442	60203	0	0	0	0	0	0
0	0	0	0	0	70363	0	60199	60412	0	0	0	0	0	0
0	0	0	0	0	70449	0	60134	60208	0	0	0	0	0	0
0	0	0	0	0	70200	0	60096	60192	0	0	0	0	0	0
0	0	0	0	0	70396	0	60209	60181	0	0	0	0	0	0
0	0	0	0	0	0	0	60204	60299	0	0	0	0	0	0
0	0	0	0	0	0	0	60293	70257	0	0	0	0	0	0
0	0	0	0	0	0	0	70196	70455	0	0	0	0	0	0
0	0	0	0	0	0	0	0	70334	0	0	0	0	0	0
0	0	0	0	0	0	0	0	70374	0	0	0	0	0	0
4	2	5	9	17	24	19	27	29	15	10	6	3	5	0

Figure III-5. Nimbus-D 6-Cell Module Histogram, Current at 0.27 Volts

778	782	786	790	794	798	802	806	810	814	818	822	826	830	834
40276	40232	40171	40236	40074	40323	40308	40297	40102	40191	40328	0	0	0	0
40358	40243	40314	40325	40271	40221	40229	40223	40186	50167	40246	0	0	0	0
50359	40319	40318	40327	40316	40193	40302	40035	60407	60424	60113	0	0	0	0
50960	40389	40254	40313	40235	40281	40081	40301	70322	70049	0	0	0	0	0
50250	50353	40315	40267	40284	40320	50194	40272	0	0	0	0	0	0	0
50247	50454	40317	40244	40198	40278	50032	40187	0	0	0	0	0	0	0
50356	70392	50270	40311	40343	40226	60096	50294	0	0	0	0	0	0	0
60436	70364	50366	50332	50357	40326	60181	50344	0	0	0	0	0	0	0
60431	0	50331	50393	50324	40128	60300	50335	0	0	0	0	0	0	0
70391	0	50382	50339	50347	50336	60460	50346	0	0	0	0	0	0	0
70017	0	50361	50225	50408	50340	70050	60202	0	0	0	0	0	0	0
70452	0	50348	50125	50201	50349	70374	60041	0	0	0	0	0	0	0
70994	0	50370	50386	50185	50354	0	60165	0	0	0	0	0	0	0
0	0	50383	50099	60015	50268	0	60136	0	0	0	0	0	0	0
0	0	50224	50156	60199	50261	0	60398	0	0	0	0	0	0	0
0	0	50388	50020	60203	50355	0	0	0	0	0	0	0	0	0
0	0	50249	60365	60192	50309	0	0	0	0	0	0	0	0	0
0	0	50296	60414	60351	60341	0	0	0	0	0	0	0	0	0
0	0	50195	60438	60461	60406	0	0	0	0	0	0	0	0	0
0	0	60440	60022	60204	60151	0	0	0	0	0	0	0	0	0
0	0	60443	60422	60299	60307	0	0	0	0	0	0	0	0	0
0	0	60378	60184	60435	60442	0	0	0	0	0	0	0	0	0
0	0	60451	60350	70100	60082	0	0	0	0	0	0	0	0	0
0	0	60345	60379	70196	60205	0	0	0	0	0	0	0	0	0
0	0	60437	60209	70423	60412	0	0	0	0	0	0	0	0	0
0	0	70432	60293	0	60208	0	0	0	0	0	0	0	0	0
0	0	70416	70368	0	60134	0	0	0	0	0	0	0	0	0
0	0	70434	70363	0	60403	0	0	0	0	0	0	0	0	0
0	0	70450	70449	0	70257	0	0	0	0	0	0	0	0	0
0	0	70200	70396	0	70455	0	0	0	0	0	0	0	0	0
0	0	0	70295	0	70334	0	0	0	0	0	0	0	0	0
13	8	30	31	25	31	12	15	4	4	3	0	0	0	0

Figure III-6. Nimbus-D 6-Cell Module Histogram, Current at 0.37 Volts

726	730	734	738	742	746	750	754	758	762	766	770	774	778	782
40232	50348	40171	40302	40297	40236	40074	40223	40102	40229	60151	60113	0	0	60407
40319	50408	40308	40284	40193	40325	40323	40328	40187	40191	0	60460	0	0	0
50360	0	40226	40198	40318	40327	40246	40281	50167	60155	0	0	0	0	0
50250	0	40244	50270	40276	40221	40326	40035	60365	70049	0	0	0	0	0
60431	0	50247	50224	40243	40314	40186	40278	60406	0	0	0	0	0	0
70017	0	50020	50309	40317	40254	40081	40128	60442	0	0	0	0	0	0
0	0	50185	50099	40316	40320	50357	50340	60041	0	0	0	0	0	0
0	0	60209	50201	40313	40271	50324	50370	60136	0	0	0	0	0	0
0	0	60293	50195	40267	40315	50336	50346	60096	0	0	0	0	0	0
0	0	70416	60015	40272	40301	50331	50268	60437	0	0	0	0	0	0
0	0	70200	60205	40311	40389	50339	50355	0	0	0	0	0	0	0
0	0	0	60203	40235	40358	50382	50032	0	0	0	0	0	0	0
0	0	0	60208	50393	40343	50361	60424	0	0	0	0	0	0	0
0	0	0	60192	50125	50332	50349	60082	0	0	0	0	0	0	0
0	0	0	60299	50383	50353	50344	60440	0	0	0	0	0	0	0
0	0	0	70196	50261	50359	50354	60443	0	0	0	0	0	0	0
0	0	0	70450	50249	50366	50347	60181	0	0	0	0	0	0	0
0	0	0	70295	50296	50294	50335	60403	0	0	0	0	0	0	0
0	0	0	0	50454	50225	50386	70423	0	0	0	0	0	0	0
0	0	0	0	60307	50356	50156	70363	0	0	0	0	0	0	0
0	0	0	0	60202	50388	60341	0	0	0	0	0	0	0	0
0	0	0	0	60184	50194	60438	0	0	0	0	0	0	0	0
0	0	0	0	60436	60414	60022	0	0	0	0	0	0	0	0
0	0	0	0	60204	60199	60422	0	0	0	0	0	0	0	0
0	0	0	0	70392	60350	60379	0	0	0	0	0	0	0	0
0	0	0	0	70100	60412	60398	0	0	0	0	0	0	0	0
0	0	0	0	70050	60134	60461	0	0	0	0	0	0	0	0
0	0	0	0	70396	60378	60300	0	0	0	0	0	0	0	0
0	0	0	0	70364	60451	60435	0	0	0	0	0	0	0	0
0	0	0	0	0	60351	70334	0	0	0	0	0	0	0	0
0	0	0	0	0	60345	70368	0	0	0	0	0	0	0	0
0	0	0	0	0	70391	70374	0	0	0	0	0	0	0	0
0	0	0	0	0	70257	70394	0	0	0	0	0	0	0	0
0	0	0	0	0	70432	0	0	0	0	0	0	0	0	0
0	0	0	0	0	70455	0	0	0	0	0	0	0	0	0
0	0	0	0	0	70434	0	0	0	0	0	0	0	0	0
0	0	0	0	0	70322	0	0	0	0	0	0	0	0	0
0	0	0	0	0	70452	0	0	0	0	0	0	0	0	0
0	0	0	0	0	70449	0	0	0	0	0	0	0	0	0
6	2	11	18	29	39	33	20	10	4	1	2	0	0	1

Figure III-7. Nimbus-D 6-Cell Module Histogram, Current at 0.46 Volts

590	591	592	593	594	595	596	597	598	599	600	601	602	603	604
40301	40302	40246	40328	40308	40297	40323	40221	40229	40171	40236	40074	40278	50357	60406
60307	40343	40319	40272	40316	40325	40223	40318	40314	40281	40327	40276	40317	50366	60407
0	50270	40198	50194	40313	40232	40193	40226	40320	40102	40358	60350	50353	60365	70392
0	60299	50294	50020	40244	40243	40035	40326	40271	40191	50331	60345	50359	60184	0
0	0	60208	60113	50250	40311	40254	40186	40315	50339	50360	60437	50355	60443	0
0	0	70017	70434	50261	40284	40128	40187	40257	50361	50382	70396	60341	70423	0
0	0	70200	0	50296	50393	50332	50348	40235	50370	50125	70364	60422	0	0
0	0	0	0	50201	50324	50344	50225	40389	50354	50386	0	60440	0	0
0	0	0	0	60424	50167	50347	50247	40081	50345	50356	0	60436	0	0
0	0	0	0	60192	50099	50408	50383	50336	50268	50388	0	60403	0	0
0	0	0	0	60096	50454	60134	50309	50340	50156	60022	0	70368	0	0
0	0	0	0	70432	60203	60300	50249	50349	60414	60442	0	0	0	0
0	0	0	0	70050	60181	60293	50185	50335	60151	60379	0	0	0	0
0	0	0	0	70322	70295	70100	50195	50224	50041	60351	0	0	0	0
0	0	0	0	0	0	70450	60015	50032	60451	60431	0	0	0	0
0	0	0	0	0	0	0	60199	60438	70415	70391	0	0	0	0
0	0	0	0	0	0	0	60202	60378	70449	70334	0	0	0	0
0	0	0	0	0	0	0	60082	60136	70374	70363	0	0	0	0
0	0	0	0	0	0	0	60205	60204	70049	0	0	0	-0	0
0	0	0	0	0	0	0	60412	60435	70394	0	0	0	0	0
0	0	0	0	0	0	0	60165	70455	0	0	0	0	0	0
0	0	0	0	0	0	0	60398	70452	0	0	0	0	0	0
0	0	0	0	0	0	0	60209	0	0	0	0	0	0	0
0	0	0	0	0	0	0	60461	0	0	0	0	0	0	0
0	0	0	0	0	0	0	60460	0	0	0	0	0	0	0
0	0	0	0	0	0	0	70257	0	0	0	0	0	0	0
0	0	0	0	0	0	0	70196	0	0	0	0	0	0	0
2	4	7	6	14	14	15	27	22	20	18	7	11	6	3

Figure III-8. Nimbus-D 6-Cell Module Histogram, Open Circuit Voltage